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NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 5-94

EVALUATION OF BAUER K-20 DIESEL DRIVE
HIGH PRESSURE BREATHING AIR COMPRESSOR

GEORGE D. SULLIVAN
DECEMBER 1993

94-20482



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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT

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IN REPLY REFER TO:

NAVSEA TASK 92-002 & 92-003

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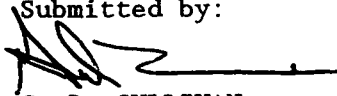
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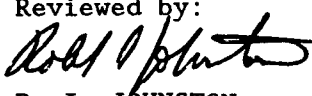
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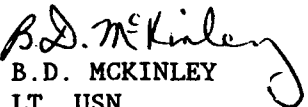
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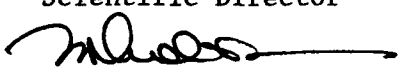

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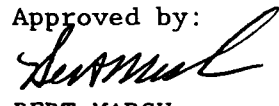

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In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) evaluated the BAUER K-20 Diesel Drive High Pressure Breathing Air Compressor from Oct 13, 1993 to Nov 02, 1993. This test was to determine if the compressor system, when operating at 5000 PSI, met Navy diving community requirements. Based on the test results NEDU recommends that the compressor not be placed on the Approved for Navy Use list published by NAVSEA OOC.				
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No. Page No.

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Air Flow Diagram

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I. INTRODUCTION

In response to NAVSEA tasking^{1 2} two BAUER 20 CFM, MODEL K-20, NSN 4310-01-291-8028 Diving Air compressors equipped with Bauer P-5 purification systems were tested by the Navy Experimental Diving Unit (NEDU). The purpose of the test was to:

- A. Determine if the compressor and Purification System provides compressed air at the required pressures, flow rates, quality and cleanliness required by the U.S. Navy³.
- B. Determine the adequacy of the manufacturer's information, instructions and guidance for the safe operation and overall management of the compressor.

II. EQUIPMENT DESCRIPTION

A. GENERAL

The BAUER 20 CFM MODEL K-20 high pressure, breathing air compressor (Figure 1) is of a four stage, four cylinder, "X" configuration. The fourth stage cylinder is lubricated by means of a forced-fed lubrication system; the other cylinders and running gear are mist-lubricated.

The BAUER compressor unit consists of compressor block, condensate separator system, purification system, instrument panel, fuel tank, and a diesel engine in a skid-mounted frame.

The drive unit during this test was a Deutz, Model F2L912, 27 hp, air cooled, two-cylinder diesel engine. The engine is designed to start electrically by means of a 12 v battery, or manually with a hand crank. It is equipped with a cold weather starting aid system. A V-belt pulley and hand-operated Rockford clutch transfers rotating torque to the compressor via two V-belts.

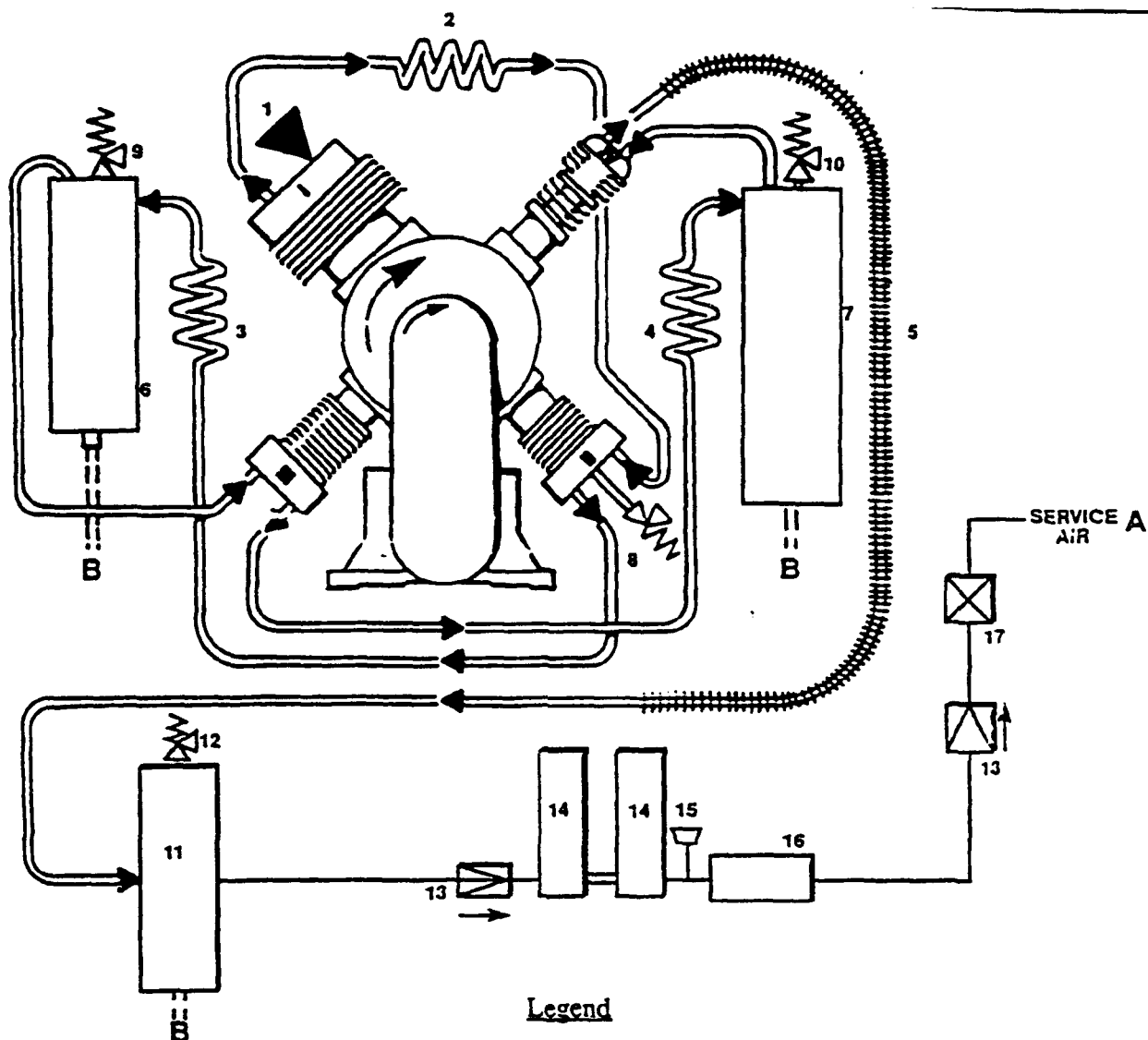
The purification system utilizes two replaceable cartridges (BAUER filter PART No. 058825 with molecular sieve, and PART No. 068416 with activated carbon and hopcalite).

The oil/water separator block is installed between the 2nd, 3rd, and 4th stages. The drawn-off oil/water is maintained in the separator blocks until the condensate drain is manually activated. The oil/water separator block is equipped with a condensate heater for use in cold weather to prevent the condensate from freezing. The separator block requires routine maintenance consisting of periodic draining. Residual oil and water vapors that are not drained manually are removed by the purification cartridge system. The treated air is free of oil, taste, smell, and carbon monoxide.

The BAUER 20 CFM, MODEL K-20 Diving Air Compressor comes with one Technical Manual⁴ which is divided into the following sections;

1. Equipment Description and Data
2. Description and Use of the Operator's Controls and Indicators
3. Preventive Maintenance Checks and Services

AIR FLOW DIAGRAM



Legend

- | | |
|--|---|
| 1. Intake Filter | 9. Interm. Pressure Safety Valve (2nd stage) |
| 2. Intercooler (1st stage) | 10. Interm. Pressure Safety Valve (3rd stage) |
| 3. Intercooler (2nd stage) | 11. Condensate Block (4th stage) |
| 4. Intercooler (3rd stage) | 12. Final Pressure Relief |
| 5. After Cooler | 13. One-Way Valve |
| 6. Condensate Block (2nd/3rd stage) | 14. Filters |
| 7. Interfilter (3rd/4th stage) | 15. Bleed Off Valve |
| 8. Interm. Pressure Safety Valve (1st stage) | 16. Pressure Maintaining Valve |
| | 17. Service Valve |

A Air Outlet

B Condensate Outlet

Note: Condensate Blocks 6, 7, and 11 are actually mounted on a heated condensate drain manifold along with the final separator.

4. Operation Under Normal Conditions
5. Fuel Oil and Lubrication Requirements
6. Unit Troubleshooting Procedures
7. Unit Maintenance Procedures

According to the manufacturer's literature⁴, the BAUER, Model K-20 compressor has a capacity of 566 liters per minute (20 scfm) free air delivered. The purification cartridges have an air processing capability for 80 hours of use or six months.

A pressure maintaining/non-return valve (which is set between 124 and 134 bars [1,800 and 2,000 psi]) is provided down-stream from the purification filter system. This achieves constant, optimum filtering, moisture separation, fourth stage piston ring expansion/cylinder sealing, and prevents compressed air return from the air storage flasks to the compressor during unit shut down. All four stages of the compressor are protected by safety relief valves. A diagram of the compressor system is provided in Figure 1. The compressor comes with two final system safety valves. The scuba charging whip relief is set at 220 bar (3,200 psig) and the air service line relief is set at 346 bar (5,100 psig).

III. TEST PROCEDURE RESULTS

Two compressor units were tested⁵. For identification purposes they are referred to as compressor (A) and compressor (B).

There are various methods of testing compressor capacities, stability, and reliability⁵. For this compressor evaluation, NEDU chose to continuously run the compressors for extended periods, charging a 87.7 liter (3.1 cuft) cylinder from 0 to 345 bars (0 to 5,000 psig). BAUER purification cartridges (PART No. 058825 and 068416) were used for these tests.

Compressor (A) and all ancillary equipment was received and set up according to manufacturer's instructions. A Cole Palmer Model 8502-14 temperature monitor and Yellow Springs Instruments 700 Series thermistor probes were attached for measuring compressor discharge and ambient temperatures. An Analox carbon monoxide monitor was used to analyze compressor discharge air before and after the filter purification system with the sample flow rate set at 3.0 mL per minute. Nitrogen with a 50.8 PPM mixture of Carbon Monoxide (CO) was used to calibrate the high range of the monitor, and ambient air was used to set the monitor's low range at 0.

A gas mixture of 24.4% carbon monoxide and 75.6% nitrogen was injected into the compressor intake by a Victor Equipment Company manual regulator through a Fisher/Porter flow meter.

The introduction of carbon monoxide was adjusted to maintain 50 PPM of carbon monoxide at the inlet to the central purification system. Appendix A and B shows the recorded data from the Test Log. The unit was operated in an exterior work area, open to ambient temperature and humidity. The testing included subjective evaluation of the system operation but did not include detailed mechanical review of the individual components of the system.

Testing of compressor (A) was suspended at 29.6 test hours because of the failure of the automatic condensate drain (ACD) block securing bolts, excessive vibration, and repeated oil line fitting failure.

Compressor (B) was configured with the testing instrumentation used on compressor (A) and the compressor was operated for a total of 50 hours. Appendix B shows recorded data from the Test Log.

Compressor (A) testing resumed after the mechanical deficiencies were corrected by a factory on-site representative. The following parameters were recorded:

1. Date
2. Time
3. Meter Test Hours
4. Ambient Temperature
5. Compressor Air Discharge Temperature
6. Ambient Humidity
7. Carbon Monoxide PPM (Before/After Filtration)
8. Injected Carbon Monoxide Flow Rate and Percentage
9. Engine Oil Pressure
10. Engine Cylinder Head Temperature
11. Alternator Output Voltage
12. Compressor Oil Pressure
13. Compressor Final Discharge Pressure
14. Service Line Discharge Pressure
15. Cylinder Charging Times

A. AIR DELIVERY

Compressor capacity was determined (27.62 scfm) by calculating the average time between compressor A (673.83 SLPM (28.82 CFM)) and B (747.95 SLPM (26.41 CFM)) to charge a (3.1 cuft) floodable volume cylinder from 0 to 345 bars (0 to 5,000 psig). Calculations are shown in Appendix A-10 and B-7.

B. AIR SAMPLING

Air samples were taken from the compressor purification system discharges. The sample on Compressor (A) was taken at 1 hour running time. Two samples were taken on Compressor (B) at the 25 hour and 45 hour test period. Samples were sent to the CSS Laboratory, Code 5130, for purity analysis. Appendix C lists the air sample analysis results. The P-5 purification system was previously evaluated in NEDU tests 91-17, 91-28 and recommended for approval in NEDU reports 08-91 and 12-91.

C. OIL LUBRICATION

At the beginning of the test⁵, compressor (A) engine oil level was 1.89 liters (2 quarts) below Full, and the compressor oil was .47 liters (1 pint) below Full. Compressor (B) engine was 2.36 liters (2.5 quarts) below Full, and the compressor was .47 liters (1 pint) below Full. Both units were filled to their prescribed limits. Oil levels were checked at the beginning and end of

each testing period, or every 8 hours. Oil consumption was logged in Appendix A and B. The engine requires 4.7 liters (5 quarts) of Navy symbol 9250. The compressor requires approximately 4.0 liters (4.2 quarts) of MIL-L-17331 2190TEP and MIL-H-17672 (Arctic Temperature) 2135TH lubricating oil.

D. OIL CONSUMPTION

During the 50 hour test⁵, a total of 0.47 liters (1 pint) of oil was added to compressor (B) and 0.23 liters (0.5 pint) of oil added to compressor (A). No engine oil was required for either unit.

E. DIESEL FUEL

The diesel engine is fitted with a 49.20 liter (13 US gallon, 10.8 Imperial gallon) fuel tank. Both compressor engines were run at the full factory throttle setting during the entire testing period. Compressor (A) used 206 liters (54.5 gallons, 45.3 imperial gallons) of diesel fuel. The average fuel consumption was 4.12 liters (1.09 gallons, 0.90 imperial gallon) per hour. Compressor (B) used 208 liters (55 gallons, 45.7 imperial gallons) of diesel fuel. The average fuel consumption was 4.16 liters (1.1 gallons, 0.91 imperial gallon) per hour.

F. MAINTENANCE

Scheduled maintenance was performed per the manufacturer's instructions⁴. This included checking the tension of drive belts, the engine/compressor oil levels, lubrication of the clutch throw-out collar, checking the engine oil bath air cleaner every 10 hours. At 24 hours, the engine oil was changed on compressor (A).

IV. OBSERVATIONS/RECOMMENDATIONS

A. Compressor (A) experienced excessive vibration contributing to component failure and complete unit failure at 29.9 hours of operation as listed in (APPENDIX A). A factory representative was called in and determined the vibration was caused by incorrect engine/compressor speed (factory set). Both compressor A and B engine "full throttle" speeds were re-adjusted by the factory representative to within factory specifications (2,100 to 2,300 RPM) then fine tuned to achieve a point of least vibration. This was accomplished at approximately 2,200 RPM as indicated on a mechanical tachometer. There is no mechanical or electrical device installed on the unit to determine or set engine/compressor speed. It is recommended that a tachometer be installed on the diesel engine and instructions provided for correctly setting the engine/compressor speed.

B. The ACD block securing bolts failed from excessive vibration and misalignment of piping. The manufacturer's maintenance manual⁴ (page 4-11 step 7) instructs the mechanic to bolt the ACD block to the compressor. Step 8 gives direction to then attach the six tubes to the ACD block. The factory representative (during his repair) first connected the six tubes to the ACD block prior to bolting it to the compressor. He said it helped relieve stress and vibration caused by misalignment. It is recommended that the Technical Manual⁴ be changed to reflect the above installation procedure.

C. The oil fill plug on the final line pressure gauge of compressor A fell out. This required replacing the gauge. The factory representative stated this was due to ambient temperature fluctuations. The failure of such instrumentation could cause equipment failure. NEDU recommends the gauges be replaced with gauges that are not subject to failure due to ambient temperature changes.

D. Gauges have no operating parameters listed. Operating parameters should be listed on each instrument i.e., ENGINE OIL PRESS 30 - 90 PSI.

E. The discharged condensation contained oily waste. The drain pipe discharged this oil/water waste on the ground leaving an oil residue and a possible safety hazard. Page 3-22 of the Technical Manual⁴ states:

The Federal Water Pollution Control Act prohibits the discharge of oil or oily waste into or upon the navigable waters of the United States etc.

Since this compressor could be used on the deck of a vessel, NEDU recommends the condensate drain be piped into a non-pressurized tank that can be emptied in a controlled manner.

F. The fuel filter is the spin off automotive type and is mounted horizontally on the engine. Replacement of this filter can not be accomplished without spilling its contents. The fuel filter should be mounted vertically.

G. Compressor B oil pressure was operating as low as 52 bars (760 psi) (Appendix B). The factory representative stated it was too low and adjusted the oil pressure regulator to 60 bars (880 psi). The Technical Manual⁴ page 2-1 states: Pressure normally reads between 51 to 59 bars (750 to 870 psi). It is recommended that the Technical Manual⁴ be corrected to reflect the correct parameters.

H. The compressor unit comes with a SCUBA charging connection, fitted with a relief valve set at 224 bars (3300 psi) and connected to a 344 bars (5000 psi) hose whip. Charging a single 2,265 liter (80 cuft) cylinder directly from the compressor would exceed the recommended charging rate⁶. This is noted for the information of all operators.

I. The fuel tank fill opening was directly over the engine exhaust manifold. There was no label warning operators to secure the engine and let it cool before adding fuel. It is recommended that the fuel tank be turned 180° in its mount. This will place the fill opening away from the engine exhaust manifold.

J. The fuel supply line has no shut off valve. It is recommended that a fuel valve be installed.

K. The rubber fuel lines rub against the skid frame. The vibration of the running unit started wearing a hole through the hose. The Army has a field modification which calls for wrapping the hose in canvas wrapping. These compressors were not modified. All compressors should be modified to include a chaffing guard on the fuel lines.

V. CONCLUSIONS

Numerous equipment failures, excessive vibration and maintenance problems occurred during both this evaluation and the one conducted in NEDU test 91-17. After the factory representative worked on both compressor A and B they seemed to operate satisfactory with less vibration than before his adjustments. Thirteen additional hours were logged on each compressor, while charging numerous Army Special Divers Air Support System (SDASS) flasks. The compressors operated satisfactory during this period. The Bauer K-20 compressor was built to the requirements of an Army specification written to provide a compressor to be used in an unusual application. The Army presently has approximately 75 of these units.

The high pressure air compressor delivers air which meets USN standards³ at an average rate of 782.11 LPM (27.62 CFM) per Appendix A and B. This meets the manufacturer's specifications. However, due to reliability and safety concerns, NEDU is recommending that the BAUER 20 CFM 5000 psi, MODEL K-20, NSN 4310-01-291-8028 not be included on the ANU list⁷. NEDU recommends that no additional compressors be procured.

VI. REFERENCES

1. NAVSEA Task 92-002. Evaluation of commercially available divers air compressors.
2. NAVSEA Task 92-003. Evaluation of Commercially Available Filters for H.P. and L.P. Breathing Air.
3. NAVSEA 0994-LP-001-9010. U.S. Navy Diving Manual Volume 1, Rev 3, Para 5.3.2. Air Purity Standards, 15 December 1988.
4. Army Technical Manual, M-5-4310-389-14 Operator, Unit and Intermediate (Direct Support/General Support) Maintenance Manual.
5. Navy Experimental Diving Unit Test Plan Number 93-34, September 1993.
6. Naval Ships Technical Manual, S9086-SY-STM-010, Chapter 551 1st Rev. 1 November 1987. Compressed Air Plants and Systems, para 551-4.2.21.
7. NAVSEAINST 10560.2B, Diving Equipment Authorized for Navy Use.
8. U.S. Army Contract Modification Number P00013 dated 23 October 1993. Issued by U.S. Army Aviation & Troop Command AMSAT-A-PSLE Ralph Macias 314-263-2535 4300 Goodfellow Boulevard St. Louis, Mo. 83120-1798.

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 13 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CONTRM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		BNO OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE DISCH PSI	CHARGED CYLINDER		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN.
		AMBI TEMP °F	COMP TEMP °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							BATED CUFT	BATED PSI	START TIME	END TIME	END PSI	
0000	23.4	64°	64°	70%	-	-	-	-	95	-	+9V	800	1,700	0	-	-	-	-	-	-
0020	23.8	72°	63°	61%	50 PPMA	0 PPMA	1.10 CC	24.4%	95	-	+9V	870	3,300	3,300	-	-	-	-	-	-
0030	24.0	66°	59°	58%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+9V	870	5,000	5,000	3.4	5,000	0854	-	-	-
0040	24.4	66°	76°	33%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+9V	870	2,300	2,300	3.4	5,000	-	-	-	-
0050	24.9	68°	81°	36%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+9V	870	4,900	4,900	3.4	5,000	-	0950	5,000	.56
1000	25.4	68°	79°	49%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	870	3,100	3,100	-	-	-	-	-	-
1040	25.9	71°	68°	47%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	870	2,000	1,300	-	-	-	-	-	-
1100	26.4	72°	59°	56%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	860	1,800	0	-	-	-	-	-	-
1120	SECURED TESTING																			
1217	STARTED TESTING																			
1230	27.2	74°	83°	58%	50 PPMA	0 PPMA	1.05 CC	24.4%	95	-	+5V	865	4,600	0	3.4	5,000	1250	-	-	-
1300	27.7	73°	83°	56%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	865	3,300	3,300	3.4	5,000	-	-	-	-
1330	28.2	73°	80°	56%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	865	2,100	2,100	3.4	5,000	-	1312	5,000	.42
1400	28.7	77°	64°	56%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	865	1,900	900	3.4	5,000	1355	-	-	-
1430	29.2	78°	80°	56%	50 PPMA	0 PPMA	1.05 CC	24.4%	90	-	+5V	865	4,400	4,400	3.4	5,000	-	1435	5,000	.42
1445	SECURED TESTING																			

REMARKS
 0709 STARTED INSTRUMENT CALIBRATION
 0750 CHECKED ENGINE & COMPRESSOR OIL (ADDED 2 QT 9250 ENGINE OIL AND 1/2 QT 2190 TEP COMPRESSOR OIL)
 0755 ADDED 10 GALLONS OF DIESEL FUEL
 1128 OIL LEAK ON COMPRESSOR OIL GAIJOS SUPPLY LINE (REPLACED SWIVEL LOCK FITTINGS)
 1305 SERVICE VALVE BAND WHEEL FEEL OFF

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 14 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMEE HUMID %	CONTRM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENG OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE INCH PSI	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN.
		AMEE TEMP °F	COMP DEGREE °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							RATED CUFT	RATED PSI	START TIME	END TIME	END PSI	
0853	29.4	68°	54°	99%	50 PPM	0 PPM	1.05 CC	24.4%	100	-	+5V	863	1,900	0	-	-	-	-	-	-
0900	29.8	69°	70°	88%	50 PPM	0 PPM	1.05 CC	24.4%	95	-	+5V	860	2,000	2,000	-	-	-	-	-	-
0909	30.4	70°	60°	89%	48 PPM	0 PPM	1.05 CC	24.4%	95	-	+5V	863	1,900	0	-	-	-	-	-	-
1000	30.8	72°	81°	83%	48 PPM	0 PPM	1.05 CC	24.4%	95	-	+5V	863	3,600	3,600	-	-	-	-	-	-
1000	31.3	73°	79°	77%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	863	2,000	2,000	3.4	5,000	1012	-	-	-
1100	31.8	74°	70°	81%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	863	1,700	1,000	3.4	5,000	-	1033	5,000	41
1130	32.3	75°	83°	81%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	863	4,400	4,400	-	-	-	-	-	-
1200	32.8	76°	84°	80%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	863	2,800	2,800	-	-	-	-	-	-
1230	33.3	77°	83°	78%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	863	3,000	3,000	-	-	-	-	-	-
1300	33.8	77°	70°	77%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	860	1,750	1,100	-	-	-	-	-	-
1330	34.3	79°	68°	76%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	860	4,600	4,600	-	-	-	-	-	-
1400	34.8	79°	88°	73%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	860	3,100	3,100	-	-	-	-	-	-
1400	35.3	79°	83°	76%	50 PPM	0 PPM	1.05 CC	24.4%	90	-	+5V	860	2,100	1,850	-	-	-	-	-	-
1443	SECURED TESTING																			

REMARKS
 0700 STARTED INSTRUMENT CALIBRATION
 0730 CHECKED ENGINE & COMPRESSOR OIL
 0735 ADDED 10 GALLONS OF DIESEL FUEL
 0833 STARTED ENGINE
 1014 ADJUSTED BACK PRESSURE REGULATOR VALVE

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 15 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER SIZ		CYLINDER CHARGING INFORMATION		CYL RLL TIME MIN
		AMBI TEMP °F	COMP DECS °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							DATED CUP	DATED PSI	START TIME	END TIME	
0741	STARTED TESTING																		
0800	55.5	74°	74°	100%	50 PPM	0 PPM	1.05 CC	24.4%	90		+3V	800	2,100	1,750					
0820	56.5	74°	69°	97%	50 PPM	0 PPM	1.05 CC	24.4%	90		+3V	800	2,100	900					
0900	56.5	74°	84°	95%	50 PPM	2 PPM	1.05 CC	24.4%	90		+3V	800	4,100	4,100	3.4	5,070	0909		
0950	57.5	74°	85°	100%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	5,000	5,000	3.4	5,000		0950	5,000
1000	57.5	75°	70°	97%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	2,100	900					
1050	58.5	75°	86°	95%	50 PPM	5 PPM	1.05 CC	24.4%	90		+3V	800	4,400	4,400					
1100	58.5	77°	85°	90%	50 PPM	5 PPM	1.05 CC	24.4%	90		+3V	800	2,000	2,000					
1150	59.5	78°	82°	91%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	2,100	1,900					
1200	59.5	78°	89°	90%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	5,000	5,000					
1250	60.5	79°	90°	86%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	5,100	5,100					
1300	60.5	80°	82°	84%	50 PPM	4 PPM	1.05 CC	24.4%	90		+3V	800	2,100	1,400					
1350	SECURED TESTING																		

REMARKS
 0749 STARTED INSTRUMENT CALIBRATION
 0750 CHECKED ENGINE & COMPRESSOR OIL
 0755 ADDED 10 GALLONS OF INTERNAL FUEL

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 18 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CO/FPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENGL OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN.
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OILS %							RATED CUFT	RATED PSI	START TIME	END TIME	END PSI	
0020	STARTED ENGINE								100		+5V									
0030	41.0	73°	71°	91%	47 PPM	0 PPM	1.00 CC	24.5%	95		+5V	865	2,100	800						
0040	41.5	73°	80°	88%	50 PPM	2 PPM	1.00 CC	24.5%	90		+5V	865	2,900	2,900						
0050	42.0	80°	72°	84%	50 PPM	0 PPM	1.00 CC	24.5%	90		+5V	860	2,100	500	3.4	5,000	0924			
1000	42.5	82°	91°	82%	48 PPM	0 PPM	1.00 CC	24.5%	90		+5V	860	4,200	4,200	3.4	5,000		1003	5,000	41
1010	43.0	84°	90°	74%	49 PPM	2 PPM	1.00 CC	24.5%	90		+5V	860	2,300	2,300						
1100	43.5	83°	83°	70%	50 PPM	4 PPM	1.10 CC	24.5%	90	160°	+5V	840	2,100	1,200						
1130	44.0	86°	97°	69%	50 PPM	0 PPM	1.10 CC	24.5%	90	160°	+5V	860	3,500	3,500						
1200	44.5	83°	87°	69%	50 PPM	0 PPM	1.10 CC	24.5%	90	160°	+5V	840	2,100	1,400						
1230	45.0	86°	78°	69%	50 PPM	0 PPM	1.10 CC	24.5%	90	160°	+5V	840	2,000	500						
1300	45.5	86°	96°	71%	50 PPM	0 PPM	1.10 CC	24.5%	90	160°	+5V	860	3,600	3,600						
1330	46.0	83°	83°	71%	50 PPM	0 PPM	1.10 CC	24.5%	90	160°	+5V	840	2,100	1,200						
1400	46.5	83°	97°	71%	50 PPM	1 PPM	1.10 CC	24.5%	90	160°	+5V	860	4,800	4,800						
1430	47.0	86°	93°	71%	50 PPM	1 PPM	1.10 CC	24.5%	90	160°	+5V	860	3,000	3,000						
1455	SECURED TESTING																			

REMARKS

0700 STARTED INSTRUMENT CALIBRATION
0750 CHECKED ENGINE & COMPRESSOR OIL
0755 ADDED 10 GALLONS OF DIESEL FUEL

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 19 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CO2 CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENG OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE DISCH PRESS	CHARGED CYLINDER INFO		CYL FILL TIME MIN
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							RATED CUFT	RATED PRESS	
605	STARTED ENGINE		-	-	-	-	-	-	100	-	+5V	-	-	-	-	-	-
670	47.0	70°	62°	100%	47 PPM	0 PPM	1.10 CC	24.4%	100	-	+5V	800	2,000	0	-	-	-
670	47.6	74°	62°	95%	50 PPM	8 PPM	1.10 CC	24.4%	95	-	+5V	803	2,900	2,900	-	-	-
680	48.1	70°	71°	91%	50 PPM	8 PPM	1.10 CC	24.4%	90	-	+5V	800	2,000	1,500	-	-	-
681	SECURED TESTING LEAK		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
683	STARTED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
690	48.6	80°	80°	80%	50 PPM	0 PPM	1.10 CC	24.4%	95	-	+5V	803	3,900	3,900	-	-	-
690	49.1	80°	80°	78%	40 PPM	0 PPM	1.10 CC	24.4%	95	-	+5V	800	2,500	2,500	-	-	-
1000	SECURED TESTING LEAK		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1000	STARTED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1004	SECURED TESTING HOSE		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1120	STARTED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1130	50.1	80°	90°	70%	50 PPM	1 PPM	1.10 CC	24.4%	90	-	+5V	800	4,000	4,000	-	-	-
1200	50.6	80°	90°	75%	40 PPM	1 PPM	1.10 CC	24.4%	90	160°	+5V	845	2,500	2,500	-	-	-
1209	SECURED TESTING HOSE		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1225	STARTED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1230	50.9	80°	90°	71%	40 PPM	1 PPM	1.10 CC	24.4%	90	160°	+5V	800	4,100	4,100	-	-	-
1300	51.3	80°	91°	70%	40 PPM	0 PPM	1.10 CC	24.4%	90	160°	+5V	850	2,100	1,500	-	-	-
1330	51.8	80°	81°	70%	45 PPM	0 PPM	1.10 CC	24.4%	90	160°	+5V	840	1,900	0	-	-	-
1400	52.3	80°	90°	75%	40 PPM	0 PPM	1.10 CC	24.4%	90	160°	+5V	845	2,900	2,900	-	-	-
1400	52.8	80°	97°	71%	40 PPM	0 PPM	1.10 CC	24.4%	90	160°	+5V	840	2,400	2,400	-	-	-
1401	SECURED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

REMARKS

400 STARTED INSTANTANT CALIBRATION
404 CHECKED ENGINE & COMPRESSOR OIL
406 ADDED 10 GALLONS OF DIESEL FUEL
604 SECOND OIL LEAK ON COMPRESSOR OIL GAUGE SUPPLY LINE (REPLACED SWEDGE LOCK FITTING)
802 ADJUSTED BACK PRESSURE REGULATOR VALVE
1000 COOLING COIL AND STAGE AIR LINE SWEDGE LOCK FITTING LEAKING (TIGHTEN FITTING)
1004 FLEXIBLE INTAKE HOSE WORKS THROUGH AT ATTACHMENT POINT (CUT BACK HOSE AND REINSTALLED HOSE)
1200 FLEXIBLE INTAKE HOSE CAME LOSE AND FUEL OFF

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 20 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HEADED %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE DASH FE	CHARGED CYLINDER SIZ		CYLINDER CHARGING INFORMATION		CTL FILL TIME MIN.
		AMBI TEMP °F	COMP DECS °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							BATED CUFT	BATED FE	START TIME	END TIME	
0705	STARTED ENGINE								100		+3V								
0800	51.9	79°	75°	88%	50 PPM	0 PPM	1.10 CC	24.4%	95		+3V	880	2,100	0					
0806	53.0	SECURED TESTING																	

REMARKS:
0805 SEPARATOR DRAIN BLOCK SECURING BOLTS FAILED CAUSING THE DRAIN BLOCK TO SEAKE UNCONTROLLABLY
0806 SECURED TESTING

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 27 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMB READING %	COFFM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE INCH PSI	CHARGED CYLINDER SIZES		CYLINDER CHARGING INFORMATION			CTL FILL TIME MIN.
		AMB TEMP °F	COMP DEGREE °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							RATED CUFT	RATED PSI	START TIME	END TIME	END PSI	
0600	STARTED ENGINE		-	-	-	-	-	-	90	-	+5V	-	-	-	-	-	-	-	-	-
0720	53.9	69°	71°	90%	-	-	-	-	90	-	+5V	840	2,300	500	-	-	-	-	-	-
0740	SECURED ENGINE		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0805	STARTED ENGINE		-	-	-	-	-	-	90	-	+5V	-	-	-	-	-	-	-	-	-
0830	54.7	72°	-	90%	-	-	-	-	90	-	+5V	840	4,600	4,600	-	-	-	-	-	-
0900	55.3	71°	-	71%	-	-	-	-	90	-	+5V	840	2,700	2,700	-	-	-	-	-	-
0930	55.7	79°	-	65%	-	-	-	-	90	-	+5V	840	5,000	5,000	-	-	-	-	-	-
1000	56.3	79°	-	69%	-	-	-	-	90	-	+5V	840	3,600	3,600	-	-	-	-	-	-
1030	57.7	80°	-	66%	-	-	-	-	90	-	+5V	840	3,100	3,100	-	-	-	-	-	-
1100	58.3	86°	-	47%	-	-	-	-	90	160°	+5V	840	2,300	1,700	-	-	-	-	-	-
1130	59.7	86°	-	38%	-	-	-	-	90	160°	+5V	840	2,000	1,600	-	-	-	-	-	-
1200	60.3	87°	-	35%	-	-	-	-	90	160°	+5V	840	4,300	4,200	-	-	-	-	-	-
1230	60.7	83°	-	69%	-	-	-	-	90	160°	+5V	840	4,300	4,300	-	-	-	-	-	-
1300	61.3	83°	-	63%	-	-	-	-	90	160°	+5V	840	2,300	1,800	-	-	-	-	-	-
1330	61.7	84°	-	65%	-	-	-	-	90	160°	+5V	840	5,000	5,000	-	-	-	-	-	-
1400	62.3	83°	-	63%	-	-	-	-	90	160°	+5V	840	4,700	4,700	-	-	-	-	-	-
1430	62.7	83°	-	63%	-	-	-	-	90	-	+5V	840	2,000	800	-	-	-	-	-	-
1432	SECURED TESTING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

REMARKS:

NOTE: FINAL PRESSURE GAUGE OIL FILL PLUG WAS MISSING. GAUGE LEAKING OIL AND WAS CHANGED

0620 STARTED INSTRUMENT CALIBRATION

0625 CHECKED ENGINE & COMPRESSOR OIL

0740 SECURED ENGINE FOR OIL CHANGE

0905 OIL CHANGE COMPLETED. STARTED ENGINE

1250 GREASED CLUTCH THROUGH-OUT BEARING

1402 SECURED TESTING

REMARKS
 NOTE: FINAL PRESSURE GAUGE OIL FILL PLUG WAS MISSING. GAUGE LEAKING OIL AND WAS CHANGED
 0620 STARTED INSTRUMENT CALIBRATION
 0630 CHECKED ENGINE & COMPRESSOR OIL
 0740 SECURED ENGINE FOR OIL CHANGE
 0800 OIL CHANGE COMPLETED. STARTED ENGINE
 1230 GREASED CLUTCH THROUGHOUT BEARING
 1400 SECURED TESTING

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 28 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AGE READ %	COFFM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE PRESS	CHARGED CYLINDER SIZES		CYLINDER CHARGING INFORMATION			CTL FILL TIME MIN.	
		AGE TEMP °F	COMP DEGREE °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							RATED CUFT	RATED PRESS	START TIME	END TIME	END PRESS		
0651	STARTED ENGINE			-	-	-	-	-	100	-	+10V	-	-	-	-	-	-	-	-	-	
0700	06.8	59°	-	82%	-	-	-	-	95	-	+10V	800	2,200	1,400	-	-	-	-	-	-	
0720	01.3	59°	-	82%	-	-	-	-	95	-	+5V	875	5,000	5,000	-	-	-	-	-	-	
0800	01.8	61°	-	79%	-	-	-	-	95	-	+5V	800	2,200	2,200	-	-	-	-	-	-	
0820	02.3	63°	-	74%	-	-	-	-	95	-	+5V	800	2,200	0	-	-	-	-	-	-	
0900	02.8	64°	-	70%	-	-	-	-	95	-	+5V	800	5,800	5,800	-	-	-	-	-	-	
0950	03.3	70°	-	68%	-	-	-	-	95	-	+5V	800	2,100	600	-	-	-	-	-	-	
1000	03.8	72°	-	64%	-	-	-	-	95	-	+5V	800	2,500	2,500	-	-	-	-	-	-	
1050	04.3	69°	-	56%	-	-	-	-	95	-	+5V	800	2,200	0	-	3.4	5,000	1052	-	-	
1100	04.8	68°	-	52%	-	-	-	-	95	-	+5V	800	5,800	5,800	-	-	-	-	1115	5,000	41
1130	05.3	68°	-	64%	-	-	-	-	95	-	+5V	800	2,200	2,100	-	-	-	-	-	-	-
1200	05.8	69°	-	64%	-	-	-	-	95	-	+5V	800	5,500	5,500	-	-	-	-	-	-	-
1220	06.3	69°	-	64%	-	-	-	-	95	-	+5V	800	2,200	1,600	-	-	-	-	-	-	-
1300	06.8	73°	-	69%	-	-	-	-	95	-	+5V	800	4,900	4,900	-	-	-	-	-	-	-
1320	07.3	73°	-	62%	-	-	-	-	95	-	+5V	800	2,200	1,900	-	-	-	-	-	-	-
1400	07.8	73°	-	60%	-	-	-	-	95	-	+5V	800	5,000	5,000	-	-	-	-	-	-	-
1402	SECURED TESTING			-	-	-	-	-	95	-	-	-	-	-	-	-	-	-	-	-	-

REMARKS:
0650 STARTED INSTRUMENT CALIBRATION
0645 CHECKED ENGINE & COMPRESSOR OIL
0651 STARTED ENGINE & COMPRESSOR
0735 ADDED 10 GALLONS OF DIESEL FUEL

APPENDIX A - Test log

BAUER H.P. COMPRESSOR (A)

DATE 1 NOVEMBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	COFFM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENG OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE DISCH PSI	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION		CYL FILL TIME MIN
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							RATED CUFT	RATED PSI	START TIME	END PSI	
0745	STARTED ENGINE																		
0800	68.6	43°		76%					95		+5V	880	2,300	1,900					
0830	69.1	44°		75%					95		+5V	880	5,000	5,000					
0900	69.6	47°		71%					95		+5V	880	4,300	4,300					
0930	70.1	48°		66%					95		+5V	880	2,200	1,700					
1000	70.6	49°		61%					95		+5V	880	2,100	400					
1030	71.1	50°		63%					95		+5V	880	4,000	4,000					
1100	71.6	50°		63%					95		+5V	880	3,800	3,800					
1130	72.1	50°		63%					95		+5V	880	2,000	100					
1200	72.6	51°		63%					95		+5V	880	4,300	4,300					
1230	73.1	53°		61%					95		+5V	880	5,000	5,000					
1250	SECURED TESTING 30 HR								95										

REMARKS:
0700 STARTED INSTRUMENT CALIBRATION
0730 CHECKED ENGINE & COMPRESSOR OIL (ADDED 1 PINT COMPRESSOR OIL)
1230 SECURED TESTING COMPRESSOR (A) 30 HR COMPLETED

The mean time for pressurizing an 87.7 liter (3.1 cuft) flask from 0 to 345 bars (0 to 5000 psi, 341.14 ATA) is: $\frac{56+42+42+41+41+41}{5} = 44.4$ minutes, therefore, the charging rate is: $\frac{87.7 \times 341.14}{44.4} = 673.83$ SL/PM or 28.83 CFM

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 26 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBIENT %	CO2PM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CYL HEAD TEMP °F	AMP AFTER VOLTS	COMP OIL PRESS	FINAL LINE FE	SERVICE LINE DRAIN FE	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							RATED CUFT	RATED FE	START TIME	END TIME	END FE	
6945	STARTED ENGINE								90		+30									
6946	21.1	63°	60°	99%	50 PPM	0 PPM	1.10 CC	24.4%	90		+5V	800	2,100	0						
6948	21.6	63°	71°	97%	50 PPM	0 PPM	1.10 CC	24.4%	90		+5V	790	2,100	800						
6949	22.1	60°	70°	95%	49 PPM	0 PPM	1.10 CC	24.4%	90		+5V	780	2,100	1,500						
6950	22.6	60°	67°	94%	49 PPM	0 PPM	1.10 CC	24.4%	90		+5V	780	2,500	2,500						
1000	23.1	67°	77°	95%	50 PPM	0 PPM	1.10 CC	24.4%	90		+5V	780	3,600	3,500						
1001	23.6	68°	74°	93%	48 PPM	0 PPM	1.5 CC	24.4%	85		+5V	780	2,400	2,100	3.4	5,000	1011			
1100	24.1	70°	60°	85%	49 PPM	1 PPM	1.4 CC	24.4%	85		+5V	780	2,100	1,800				1051	5,000	40
1130	24.7	72°	78°	85%	46 PPM	1 PPM	1.4 CC	24.4%	85		+5V	780	2,400	2,100						
1200	25.1	72°	82°	84%	47 PPM	1 PPM	1.4 CC	24.4%	85		+5V	780	4,100	3,800						
1230	25.7	74°	79°	83%	47 PPM	1 PPM	1.4 CC	24.4%	85		+5V	780	3,200	1,900						
1300	26.1	73°	80°	83%	47 PPM	1 PPM	1.4 CC	24.4%	85		+5V	780	4,500	4,300						
1330	26.7	70°	60°	80%	48 PPM	1 PPM	1.4 CC	24.4%	85		+5V	765	2,000	200						
1400	27.2	70°	80°	78%	48 PPM	1 PPM	1.6 CC	24.4%	85		+5V	800	2,500	1,900						
1430	27.6	70°	70°	79%	25 PPM	1 PPM	1.5 CC	24.4%	85		+5V	800	2,100	1,100						
1500	28.1	70°	87°	70%	46 PPM	1 PPM	1.5 CC	24.4%	80		+5V	780	4,500	4,100						
1530	28.6	77°	85°	70%	54 PPM	1 PPM	1.5 CC	24.4%	80		+5V	800	2,800	2,500						
1600	29.1	77°	74°	75%	50 PPM	11 PPM	1.5 CC	24.4%	80		+5V	790	2,000	1,100						
1630	29.6	79°	90°	76%	50 PPM	10 PPM	1.5 CC	24.4%	80		+5V	780	5,300	4,900						
1700	30.1	70°	87°	81%	56 PPM	9 PPM	1.5 CC	24.4%	80		+5V	780	3,600	3,500						
1730	30.6	74°	83°	85%	56 PPM	10 PPM	1.5 CC	24.4%	80		+5V	790	2,600	2,400						

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 26 & 27 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PRESS	SERVICE LINE DISCH PRESS	CHARGED CYLINDER INFO		CYLINDER CHARGING INFORMATION		CYL FILL TIME MIN.
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							RATED CUFT	RATED PRESS	START TIME	END TIME	
1800	31.1	70°	67°	87%	40 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	2,000	200	-	-	-	-	-
1830	31.2	75°	66°	90%	48 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	2,000	800	-	-	-	-	-
1840	31.8	72°	84°	91%	50 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	5,100	4,900	-	-	-	-	-
1900	32.3	72°	82°	90%	54 PPM	13 PPM	1.3 CC	24.4%	85	-	+5V	780	3,600	3,300	-	-	-	-	-
2000	32.8	71°	78°	90%	50 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	2,300	1,900	-	-	-	-	-
2030	33.3	71°	84°	97%	56 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	5,100	4,800	-	-	-	-	-
2100	33.8	72°	82°	97%	53 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	4,000	3,700	-	-	-	-	-
2130	34.3	70°	80°	98%	50 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	780	2,600	2,300	-	-	-	-	-
2200	34.8	69°	63°	98%	50 PPM	10 PPM	1.3 CC	24.4%	85	-	+5V	770	2,000	400	-	-	-	-	-
2250	35.3	69°	79°	98%	50 PPM	16 PPM	1.3 CC	24.4%	85	-	+5V	780	5,200	4,900	-	-	-	-	-
2300	35.8	68°	77°	98%	50 PPM	17 PPM	1.3 CC	24.4%	85	-	+5V	770	2,900	2,600	-	-	-	-	-
2330	36.3	69°	78°	99%	50 PPM	19 PPM	1.3 CC	24.4%	85	-	+5V	760	2,500	2,200	-	-	-	-	-
2400	36.8	68°	63°	98%	50 PPM	19 PPM	1.3 CC	24.4%	85	-	+5V	760	2,000	500	-	-	-	-	-
0000	37.3	69°	80°	98%	50 PPM	17 PPM	1.3 CC	24.4%	85	-	+5V	770	5,000	4,700	-	-	-	-	-
0100	37.8	68°	79°	99%	50 PPM	16 PPM	1.3 CC	24.4%	85	-	+5V	760	3,400	3,100	-	-	-	-	-
0130	38.3	67°	73°	100%	50 PPM	17 PPM	1.3 CC	24.4%	85	-	+5V	760	2,500	2,000	-	-	-	-	-
0200	38.8	67°	62°	100%	50 PPM	19 PPM	1.3 CC	24.4%	85	-	+5V	760	2,000	500	-	-	-	-	-

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 27 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	COFFMA CONCENTRATION		CO INJECTED INTO COMP INTAKE		END OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER #72		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN.
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							BATED CUFT	BATED PSI	START TIME	END TIME	END PSI	
0250	38.3	60°	76°	100%	50 PPM	19 PPM	1.5 CC	24.4%	85	-	+5V	780	4,500	4,600	-	-	-	-	-	-
0300	38.8	63°	75°	100%	48 PPM	19 PPM	1.5 CC	24.4%	85	-	+5V	770	3,300	3,000	-	-	-	-	-	-
0330	40.3	63°	66°	100%	50 PPM	18 PPM	1.5 CC	24.4%	85	-	+5V	770	2,200	1,600	-	-	-	-	-	-
0400	41.8	63°	76°	100%	51 PPM	16 PPM	1.5 CC	24.4%	85	-	+5V	780	5,100	4,800	-	-	-	-	-	-
0430	41.9	64°	60°	100%	45 PPM	19 PPM	1.5 CC	24.4%	85	-	+5V	790	2,100	1,100	-	-	-	-	-	-
0500	41.4	64°	76°	100%	48 PPM	20 PPM	1.5 CC	24.4%	85	-	+5V	790	4,600	4,300	-	-	-	-	-	-
0530	41.9	63°	73°	100%	50 PPM	20 PPM	1.5 CC	24.4%	85	-	+5V	780	5,400	5,100	-	-	-	-	-	-
0600	42.4	64°	72°	100%	50 PPM	21 PPM	1.5 CC	24.4%	85	-	+5V	780	2,400	2,100	-	-	-	-	-	-
0630	43.0	63°	63°	100%	50 PPM	13 PPM	1.5 CC	24.4%	85	-	+5V	800	2,000	100	-	-	-	-	-	-
0700	43.3	67°	68°	99%	50 PPM	16 PPM	1.5 CC	24.4%	85	-	+5V	800	5,500	5,200	-	-	-	-	-	-
0730	43.7	69°	69°	98%	50 PPM	17 PPM	1.5 CC	24.4%	85	-	+5V	780	5,000	4,700	-	-	-	-	-	-
0800	44.2	68°	76°	98%	48 PPM	18 PPM	1.5 CC	24.4%	85	-	+5V	780	2,600	2,300	-	-	-	-	-	-
0830	44.7	72°	77°	92%	48 PPM	19 PPM	1.5 CC	24.4%	85	-	+5V	780	2,300	1,800	-	-	-	-	-	-
0900	45.2	71°	82°	71%	46 PPM	18 PPM	1.5 CC	24.4%	85	-	+5V	780	5,100	4,800	-	-	-	-	-	-
0930	45.7	73°	63°	68%	46 PPM	17 PPM	1.5 CC	24.4%	85	-	+5V	770	2,000	200	-	-	-	-	-	-
1000	46.2	79°	73°	69%	46 PPM	19 PPM	1.5 CC	24.4%	85	-	+5V	780	2,000	1,100	-	-	-	-	-	-
1030	46.7	90°	84°	66%	46 PPM	17 PPM	1.5 CC	24.4%	85	-	+5V	780	5,500	5,200	-	-	-	-	-	-

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 27 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER SIZES		CYLINDER CHARGING INFORMATION			CYL FILL TIME MIN
		AMBI TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	OAS %							RATED CUFT	RATED PSI	START TIME	END TIME	END PSI	
1100	47.2	80°	87°	47%	48 PPM	13 PPM	1.0 CC	24.4%	85	-	+5V	760	2,200	1,400	-	-	-	-	-	
1130	47.5	87°	92°	58%	47 PPM	10 PPM	1.0 CC	24.4%	80	160	+5V	760	2,100	1,200	-	-	-	-	-	
1200	48.9	87°	100°	58%	46 PPM	9 PPM	1.0 CC	24.4%	80	165	+5V	760	4,400	4,100	-	-	-	-	-	
1250	48.5	83°	99°	60%	47 PPM	8 PPM	1.0 CC	24.4%	80	165	+5V	760	4,500	4,000	-	-	-	-	-	
1300	48.0	83°	86°	65%	49 PPM	8 PPM	1.0 CC	24.4%	80	165	+5V	760	2,100	1,300	-	-	-	-	-	
1330	48.5	84°	97°	65%	49 PPM	7 PPM	1.0 CC	24.4%	80	160	+5V	760	4,900	4,600	-	-	-	-	-	
1400	50.0	83°	94°	65%	49 PPM	8 PPM	1.0 CC	24.4%	80	160	+5V	760	4,000	4,300	-	-	-	-	-	
1450	50.5	85°	87°	65%	45 PPM	7 PPM	1.0 CC	24.4%	80	-	+5V	820	2,200	1,500	-	-	-	-	-	

REMARKS:

26 OCTOBER
 0700 STARTED INSTRUMENT CALIBRATION
 0715 CHECKED ENGINE & COMPRESSOR OIL (ADDED 2 1/2 QUARTS 930 TO ENGINE AND 1 PINT 210WTER TO COMPRESSOR
 0720 ADDED 12 GAL DIESEL FUEL
 0746 STARTED ENGINE AND COMPRESSOR
 1100 ADJUSTED "V" DRIVE BELTS AND CHECKED ENGINE & COMPRESSOR OIL
 1400 GREASED CLUTCH BEARING
 2200 ADDED 16 GAL DIESEL FUEL
 27 OCTOBER
 0700 ADDED 10 GAL DIESEL FUEL
 1230 GREASED CLUTCH BEARING
 1420 ADJUSTED COMPRESSOR OIL REGULATOR
 0400 GREASED CLUTCH BEARING, CHECKED ENGINE & COMPRESSOR OIL
 1431 SECURED TESTING

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 28 OCTOBER 1993

REAL TIME	METER HOURS	TEMP °F		AGE RUND %	CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENG OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER SIZES		CYLINDER CHARGING INFORMATION			CTL FILL TIME MIN
		AGE TEMP °F	COMP DISCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							BATED CUFT	BATED PSI	START TIME	END TIME	END PSI	
0000	STARTED ENGINE								95	-	+5V	-	-	-	-	-	-	-	-	-
0700	36.6	59°	54°	82%	50 PPM	13 PPM	1.1 CC	24.4%	95	-	+5V	880	2,100	900	-	-	-	-	-	-
0720	36.9	60°	60°	82%	50 PPM	13 PPM	1.1 CC	24.4%	90	-	+5V	880	2,600	2,500	3.4	5,000	1011	-	-	-
0800	31.4	61°	59°	79%	50 PPM	13 PPM	1.1 CC	24.4%	85	-	+5V	860	1,000	0	-	-	-	1051	5,000	40
0820	31.9	63°	71°	74%	48 PPM	13 PPM	1.1 CC	24.4%	85	-	+5V	860	3,400	3,100	-	-	-	-	-	-
0900	32.4	64°	72°	70%	49 PPM	14 PPM	1.1 CC	24.4%	85	-	+5V	860	2,900	2,600	-	-	-	-	-	-
0920	32.9	70°	73°	63%	49 PPM	13 PPM	1.1 CC	24.4%	85	-	+5V	860	3,000	2,700	-	-	-	-	-	-
1000	33.4	72°	73°	64%	50 PPM	16 PPM	1.1 CC	24.4%	85	-	+5V	860	3,100	2,800	-	-	-	-	-	-
1020	33.9	69°	68°	56%	50 PPM	13 PPM	1.1 CC	24.4%	85	-	+5V	860	2,000	0	3.4	5,000	1022	-	-	-
1100	34.4	68°	77°	52%	50 PPM	17 PPM	1.1 CC	24.4%	85	-	+5V	860	3,700	3,400	-	-	-	1112	5,000	40
1130	34.9	68°	74°	64%	50 PPM	19 PPM	1.1 CC	24.4%	85	-	+5V	840	2,500	1,900	-	-	-	-	-	-
1200	35.4	69°	78°	64%	50 PPM	18 PPM	1.1 CC	24.4%	80	-	+5V	840	3,800	3,500	-	-	-	-	-	-
1220	35.9	69°	74°	64%	50 PPM	15 PPM	1.1 CC	24.4%	80	-	+5V	840	2,100	1,600	-	-	-	-	-	-
1300	36.4	74°	83°	63%	50 PPM	14 PPM	1.1 CC	24.4%	80	-	+5V	840	5,300	5,000	-	-	-	-	-	-
1330	36.9	73°	82°	62%	50 PPM	8 PPM	1.1 CC	24.4%	80	-	+5V	840	2,500	1,900	-	-	-	-	-	-
1400	37.4	73°	61°	60%	50 PPM	10 PPM	1.1 CC	24.4%	80	-	+5V	840	2,000	0	-	-	-	-	-	-

REMARKS
 0000 ADDED 7 GALL DIESSEL FUEL
 0600 CHECKED ENGINE & COMPRESSOR OIL
 0645 OBEARED CLUTCH BEARING
 0700 SECURED ENGINE FOR OIL CHANGE (COULD NOT REMOVE OIL DRAIN PLUG USING 3 CHEATER BAR
 0718 STARTED ENGINE
 1401 SECURED TESTING

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 1 NOVEMBER 1993

REAL TIME	METER HOURS	TEMP °F		AMBI HUMID %	CONCENTRATION		CO INJECTED INTO COMP. INTAKE		END OIL PRESS	CTL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE INCH PSI	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CTL RLL TIME MIN.
		AMBI TEMP °F	COMP INCH/°F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							RATED CUFT	RATED PSI	START TIME	END TIME	END PSI	
0704	STARTED ENGINE								95		+5V									
0800	38.1	43°		76%	50 PPM	8 PPM	1.0 CC	24.4%	95		+5V	890	2,200	1,600						
0820	38.6	44°	52°	75%	50 PPM	7 PPM	1.0 CC	24.4%	90		+5V	880	3,300	5,000						
0900	38.1	47°	56°	71%	50 PPM	10 PPM	1.0 CC	24.4%	85		+5V	880	4,900	4,600						
0950	39.6	48°	54°	66%	50 PPM	8 PPM	1.0 CC	24.4%	85		+5V	880	3,000	2,700						
1000	38.1	49°	40°	62%	50 PPM	10 PPM	1.0 CC	24.4%	85		+5V	880	2,000	700						
1050	38.6	50°	39°	63%	50 PPM	15 PPM	1.0 CC	24.4%	85		+5V	880	4,600	4,300						
1100	41.1	50°	39°	63%	50 PPM	20 PPM	1.0 CC	24.4%	85		+5V	880	3,700	3,400						
1150	41.6	50°	56°	63%	50 PPM	18 PPM	1.0 CC	24.4%	85		+5V	860	2,000	100						
1200	42.1	51°	61°	62%	50 PPM	18 PPM	1.0 CC	24.4%	85		+5V	860	3,900	3,600						
1250	42.6	54°	63°	61%	50 PPM	19 PPM	1.0 CC	24.4%	85		+5V	860	4,500	4,200						
1300	43.1	53°	50°	60%	50 PPM	19 PPM	1.0 CC	24.4%	85		+5V	860	2,000	1,000						
1350	43.6	54°	56°	60%	50 PPM	19 PPM	1.0 CC	24.4%	85		+5V	860	3,800	3,500						
1400	44.1	53°	63°	59%	50 PPM	19 PPM	1.0 CC	24.4%	85		+5V	860	5,000	4,700						
1450	44.6	53°	60°	59%	50 PPM	19 PPM	1.0 CC	24.4%	85		+5V	860	2,900	1,900						
1451	SECURED TESTING																			

REMARKS
 0700 ADDED 10 GAL DIESEL FUEL
 0715 CHECKED ENGINE & COMPRESSOR OIL
 0725 OIL-LEASED CLUTCH BEARING
 1451 SECURED TESTING

APPENDIX B - Test log

BAUER H.P. COMPRESSOR (B)

DATE 2 NOVEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	COMPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		ENG OIL PRESS	CYL HEAD TEMP °F	AMP METER VOLTS	COMP OIL PRESS	FINAL LINE PSI	SERVICE LINE DISCH PSI	CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION		CYL FILL TIME MIN
		AMBI TEMP °F	COMP DSCH °F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %							RATED CUFT	RATED PSI	START TIME	END TIME	
0655	STARTED ENGINE								95		+5V								
0700	64.7	50°	54°	67%	50 PPM	18 PPM	1.1 CC	24.4%	95		+5V	890	2,200	0					
0730	65.2	50°	56°	67%	50 PPM	19 PPM	1.1 CC	24.4%	90		+5V	880	2,300	1,900					
0800	64.7	56°	62°	66%	50 PPM	28 PPM	1.1 CC	24.4%	85		+5V	880	4,200	3,900					
0830	66.2	60°	65°	64%	46 PPM	27 PPM	1.1 CC	24.4%	85		+5V	860	2,700	2,400					
0900	66.7	62°	66°	63%	48 PPM	24 PPM	1.1 CC	24.4%	85		+5V	860	4,000	3,700					
0930	67.2	56°	55°	62%	49 PPM	26 PPM	1.1 CC	24.4%	85		+5V	840	1,900	1,000					
1000	67.7	57°	65°	60%	50 PPM	27 PPM	1.1 CC	24.4%	85		+5V	840	2,900	2,600					
1030	68.2	58°	68°	61%	50 PPM	27 PPM	1.1 CC	24.4%	85		+5V	840	5,100	4,800					
1100	68.7	59°	57°	61%	50 PPM	28 PPM	1.1 CC	24.4%	85		+5V	840	2,000	1,000					
1130	69.2	59°	78°	60%					85		+5V	840	1,800	1,000					
1200	69.7	60°	69°	59%					85		+5V	840	3,900	3,500					
1230	70.2	60°	70°	59%					85		+5V	840	2,000	1,700					
1300	70.7	60°	71°	58%					85		+5V	840	3,500	3,200					
1330	71.2	SECURED TESTING							85		+5V	840	5,300	5,000					

REMARKS:

0630 CHECKED ENGINE & COMPRESSOR OIL (ADDED 1 PINT COMPRESSOR OIL)
 0635 GREASED CLUTCH BEARING
 0640 ADDED 10 GAL DIESEL FUEL
 0655 STARTED ENGINE
 0650 AIR SAMPLE TAKEN
 1200 SECURED CO INJECTION
 1330 SECURED TESTING, 50 HR.

The mean time for pressurizing an 87.7 liter (3.1 cuh) flask from 0 to 345 bars (0 to 5000 psi, 341.14 ATA) is $\frac{40+40+40}{3} = 40$ minutes, therefore, the charging rate is $\frac{87.7 \times 341.14}{40} = 747.95$ SL/PM or 26.41 CFM

MEMORANDUM

14 October 1993

From: G. Deason, Code 2530
To: Dave Sullivan, NEDU

Subj: Analysis of air sample from Bauer K-20 compressor (1 hour evaluations).

1. In accordance with your request, the air sample received at the gas analysis lab was analyzed and found to contain:

Standard Components

Components	Level	Limit
Oxygen	21.0%	20-22%***
Nitrogen	78.1%	NONE***
Argon	0.9%	NONE***
Carbon Dioxide	63.0 PPM	1000 PPM***
Total Hydrocarbons*	1.8 PPM	25 PPM**
Carbon Monoxide	<0.5 PPM	20 PPM**
Methane	1.8 PPM	1000 PPM**
Acetone	<0.1 PPM	200 PPM***
Benzene	<0.1 PPM	1 PPM***
Chloroform	<0.1 PPM	1 PPM***
Ethanol	<0.1 PPM	100 PPM***
Freon 113	<0.1 PPM	10 PPM***
Freon 11	<0.1 PPM	100 PPM***
Freon 12	<0.1 PPM	100 PPM***
Freon 114	<0.1 PPM	100 PPM***
Isopropyl Alcohol	<0.1 PPM	1 PPM***
Methanol	<0.1 PPM	10 PPM***
Methyl Chloroform	<0.1 PPM	30 PPM***
Methyl Ethyl Ketone	<0.1 PPM	20 PPM***
Methyl Isobutyl Ketone	<0.1 PPM	20 PPM***
Methyl Chloride	<0.1 PPM	25 PPM***
Toluene	<0.1 PPM	20 PPM***
Trimethyl Benzenes	<0.1 PPM	3 PPM***
Xylenes	<0.1 PPM	50 PPM***

Other Components

Component	Level	Limit
C4+	<0.1 PPM	<0.1
PPM		

*Expressed as methane equivalents.

**Limits from process instruction #0558-839.

***Limits from Navy Dive Manual; Vol 2, Rev 3.

****OSHA Final Rule limits published as of July 1992 (not specified in Navy Dive Manual.)

2. The sample showed no appreciable contamination. All components were within the acceptable range.



Glen Deason
Chemist

Memorandum

27 October 1993

To: Dave Sullivan, NEDU

From: Glen Deason, Code 2530

Subject: Analysis of air sample from the Bauer K-20 #B
compressor evaluation test, 25 hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

Component	Level	Limit
Oxygen	21%	20-22%***
Nitrogen	78.1%	NONE***
Argon	0.9%	NONE***
Carbon Dioxide	505 PPM	1000 PPM***
Total Hydrocarbons*	1.9 PPM	25 PPM**
Carbon Monoxide	21.6 PPM	20 PPM**
Methane	1.9 PPM	1000 PPM**
Acetone	<0.1 PPM	200 PPM***
Benzene	<0.1 PPM	1 PPM***
Chloroform	<0.1 PPM	1 PPM***
Ethanol	<0.1 PPM	100 PPM***
Freon 113	<0.1 PPM	100 PPM***
Freon 11	<0.1 PPM	100 PPM***
Freon 12	<0.1 PPM	100 PPM***
Freon 114	<0.1 PPM	100 PPM***
Isopropyl Alcohol	<0.1 PPM	1 PPM***
Methanol	<0.1 PPM	10 PPM***
Methyl Chloroform	<0.1 PPM	30 PPM***
Methyl Ethyl Ketone	<0.1 PPM	20 PPM***
Methyl Isobutyl Ketone	<0.1 PPM	20 PPM***
Methylene Chloride	<0.1 PPM	25 PPM***
Toluene	<0.1 PPM	20 PPM***
Trimethyl Benzenes	<0.1 PPM	3 PPM***
Xylenes	<0.1 PPM	50 PPM***

Other Components

Component	Level	Limit
NONE		
C4+	<0.1 PPM	NONE

*Expressed as methane equivalents.
**Limits taken from process instruction #0558-839.
***Limits taken from Navy Dive Manual; Vol. 2, Rev. 3.
**** OSHA Final Rule limits published as of July 1992 (not specified in Navy Dive Manual).

2. The above sample showed appreciable contamination; all components were not within the acceptable range.


Glen Deason
Chemist